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# **The epidemiology of professional ice hockey injuries: A prospective report of six National Hockey League seasons**

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## Abstract

**BACKGROUND:** There is a paucity of literature examining injury and illness rates in men's professional ice hockey. This study aimed to determine injury and illness rates in the National Hockey League (NHL) over six seasons, and identify predictors of injury-related time loss in this population.

**METHODS:** This study involved an inclusive cohort of hockey players from all NHL teams competing in the 2006-2007 through 2011-2012 seasons. A standardized electronic injury surveillance system was used to report injury and illness events. The primary outcome was regular season and postseason time-loss injury/illness. The secondary outcome was man-games lost from competition.

**RESULTS:** Based on estimated Athlete Exposures (AE), the overall regular season incidence density was 15.6 injuries/1000 and 0.7 illnesses/1000 AE. Based on recorded time on ice, rates were roughly three-fold higher at 49.4 injuries/1000 player game-hours and 2.4 illnesses/1000 player game-hours. There was a reduction in injury rates over the six-year period, with the greatest reduction between the 2007-2008 and 2008-2009 seasons. Multivariate predictors of time loss greater than 10 days were being a goalie (odds ratio [OR] = 1.68, 95% CI: 1.18, 2.38), being injured in a road game (OR = 1.43, 95% CI: 1.25, 1.63), and mechanism of injury being a body check (OR = 2.21, 95% CI: 1.86, 2.62).

**CONCLUSIONS:** There was an overall reduction in time-loss injury and illness rates over six seasons. Being a goaltender, being injured on the road, and being injured by a body check were risk factors for time loss greater than five man-games.

### What are the new findings?

- Injury rate estimates were approximately three times greater when using recorded time on ice instead of estimated exposure hours as the denominator
- There was a significant reduction in time-loss injury and illness rates over the six-year period of the study
- Being a goalie, being injured in a road game, and being injured by a body check were significant predictors of time loss greater than 10 days

### **How might it impact on clinical practice in the near future?**

- Injury rate estimates should be standardized to injuries/1000 athlete exposures [AE] to enable between-study comparisons
- Medical management of injuries sustained in road games should reflect the increased risk of time loss greater than 10 days associated with injuries sustained away from the home arena
- Injury prevention efforts should focus on head, thigh, and knee injuries

Pre-publication

## **BACKGROUND**

Ice hockey is a collision sport where knowledge of injury patterns is important to provision of appropriate medical care. Injury rates in collegiate and professional men's leagues have reportedly ranged from 2.3 – 79.2 injuries/1000 player hours,[1-9] but there have been large discrepancies in the injury definitions and surveillance techniques used in previous studies. Time loss following injury has been reported descriptively or has been used as an indicator of injury severity, but predictors of injury time loss have not yet been identified for elite level players.[1-9]

In addition, little is known about the rate of illness in this population. Engebretsen and colleagues [10] reported that 3% of athletes competing in men's ice hockey during the 2010 Winter Olympic Games reported an illness, but no other study has been published with an epidemiologic approach to determining illness incidence in elite hockey leagues.

The purpose of this study was to determine the rates of injury and illness in the National Hockey League (NHL) over 6 seasons. The secondary aim was to identify predictors of injury time loss in this population.

## **METHODS**

### **Study design and participants**

This was a prospective case series examining injury and illness incidence in an inclusive cohort of male professional ice hockey players from all teams competing in the NHL during the 2006-2007 through 2011-2012 seasons.

In 2006, an electronic medical record [the "Athlete Health Management System" (AHMS)] was implemented, which has an injury surveillance component. NHL Athletic Team Trainers/Therapists and Team Physicians documented all injuries using a standardized "Injury/Illness Event" (IIE) form for each event causing a player to miss one or more games. Medical staff were also instructed to create an IIE for each event needing medical assessment and treatment, regardless of time loss.

Team Athletic Trainers/Therapists and Physicians were present at all regular season and postseason games, and documented the date, time and period of play in which injuries occurred. All injury/illness diagnoses were coded using the UofC Sport Medicine Diagnostic Coding System.[11] They also recorded the date on which players were medically cleared to return to unrestricted competition. The AHMS uses the interval between these dates, cross-referenced to the team's competitive calendar, to calculate the number of games missed for each injury or illness (one "man game" = one player missing one game).

Data were downloaded at the end of the season using the AHMS extraction feature that generates a Microsoft Excel spreadsheet (Microsoft Excel 2011, Redmond, WA, USA). Simple descriptive analysis was done in Excel whereas regression analysis was done in Stata v.13 (StataCorp 2013, College Station, TX, USA). The extraction of data and analysis was approved by the Office of Medical Bioethics at the University of Calgary (Ethics ID # 18969).

## Outcome Measures

The primary outcome variables were injury and illness, defined as any event captured by the IIE form, and restricted to those designated as practice or game-related, resulting in one or more man games lost. Injuries were defined as practice or game-related based on the activity at time of injury, and illnesses were defined as such based on whether they were reported by the player to have occurred at either a game or practice session. Only regular season and postseason events were included. The secondary outcome was time loss, as measured in man-games lost (MGL) from competition.

The independent variables of interest, all extracted from the AHMS, were age, position played, mechanism of injury, affected body region, home versus away game, period of the game, and part of the season (ie: regular season versus postseason).

## Analysis

Descriptive statistics are presented as frequencies and proportions. Overall incidence of game and practice-related injury and illness is presented, but subsequent analyses were restricted to those designated as game-related only, due to the unavailability of practice exposure time. Athlete game exposure time was calculated using two different methods:

- 1) Athlete exposures based on all NHL teams playing 82 regular season games per season, with 18 skaters and one goaltender playing for each team in each game.[12] Postseason exposures were estimated based on the number of playoff games that occurred each season, with a reduction in the number of active players as teams were eliminated from playoff contention. Because each game consisted of three 20-minute stop-time periods (ie: one hour exposure per game, per player), the number of athlete exposures was equivalent to player-hours, with no adjustment for games that contained overtime minutes.
- 2) Using actual time on ice (TOI) from the [www.NHL.com](http://www.NHL.com) player statistics page, where the minutes and seconds played by each player was summed across each season to calculate actual hours on the ice.

The incidence density of game-related injury was calculated as the number of injury events divided by the sum of individual athlete-exposure time, allowing for re-entry into exposure for players who had returned to unrestricted competition.

It was not possible to offset analyses for individual exposure time, as the AHMS data set does not include a record of ice time. The [www.NHL.com](http://www.NHL.com) statistics page only lists exposure by player name, and therefore this information could not be linked to the de-identified AHMS data. Therefore, logistic regression, adjusting for diagnostic code, affected body region, and cluster by team, was used to identify the odds ratio (OR) associated with potential predictors of MGL. For OR calculations, a five MGL cut-point, which corresponded to an average 10 days of time loss, was established because 10 or more days of time loss would constitute a “moderate” or “severe” injury using classifications previously used in ice hockey, [7,9,12]. Risk factors (age, playing position, mechanism of injury, home vs. away game, period of

play) were included in a multivariable model in a stepwise fashion to determine the effect of potential predictors on injury risk.

## RESULTS

### *Player characteristics*

A total of 1,685 individual players were included in the data set ( $n=840$ ,  $n=843$ ,  $n=837$ ,  $n=838$ ,  $n=891$ ,  $n=895$  in each season, respectively). The sample included 1,025 forwards, 566 defensemen, and 94 goalies. The mean age of those reporting an injury or an illness was 31.4 years ( $SD=5.1$ ; range: 19-50; IQR: 28-36).

### *Injury and illness incidence*

Overall, there were 5,184 on-ice time loss injuries and 376 game or practice-related time loss illnesses reported over the six years of this study. Of these, 163 (3.1%) injuries were recorded by the medical staff as re-injuries. The majority of injuries occurred during games (88.7%), compared to practices (11.3%). A total of 40,943 man games were lost due to injury and illness during the study period (Table 1).

Based on estimated athlete exposures (AE), the overall regular season game-related injury incidence density during the study period was 15.6 injuries per 1000 AE and 0.7 illnesses per 1000 AE, but there were differences between seasons (Table 2). The incidence density of injury [incidence density ratio (IDR) = 1.34; 95% CI: 1.17, 1.53] and illness (IDR = 2.11; 95% CI: 1.01, 5.31) were significantly greater during the regular season than the postseason.

When examined by recorded time on ice (TOI), regular season game-related injury incidence density was significantly higher (49.4/1000 player game-hours) than using AE (Table 3). However, compared to the estimated AE values, distributions of injuries and illnesses in the regular season and postseason were unchanged using recorded TOI.

Based on injury incidence values presented in Table 2, the injury density during the first two years of this study appeared to be much larger than that in the final four years. There was a significant reduction in incidence during the regular season (IDR = 1.66; 95% CI: .56, 1.76) and postseason (IDR = 2.10; 95% CI: 1.60, 2.73), comparing the first two to the last four years. A similar pattern was seen for illness in the regular season (IDR = 1.53; 95% CI: 1.15, 2.03), but not the postseason (IDR = 1.54; 95% CI: 0.22, 9.10).

Table 1. Man-games lost (MGL) by season.

	2006- 2007	2007- 2008	2008- 2009	2009- 2010	2010- 2011	2011- 2012
<b>Regular season total</b>	7253	7831	6306	5877	6565	6289
<b>Game</b>	5986	7029	5296	5153	5713	5555
<i>Injury</i>	5927	6812	5213	5089	5567	5448
<i>Illness</i>	59	217	83	64	146	107
<b>Practice</b>	1267	802	1010	724	852	734
<i>Injury</i>	1031	723	945	654	823	708
<i>Illness</i>	236	79	65	70	29	26
<b>Post season total</b>	170	185	103	147	121	96
<b>Game</b>	152	141	89	137	112	87
<i>Injury</i>	150	140	87	135	112	87
<i>Illness</i>	2	1	2	2	0	0
<b>Practice</b>	18	44	14	10	9	9
<i>Injury</i>	14	42	14	9	9	6
<i>Illness</i>	4	2	0	1	0	3



Table 2. Game-related injury incidence density per 1000 athlete exposures and 1000 recorded player-hours. \*includes overtime minutes

Regular Season	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	Overall
Injuries	988	991	599	605	592	593	4368
Estimated athlete exposures (AE)	46740	46740	46740	46740	46740	46740	280440
Injury incidence density (per 1,000 AE)	21.1	21.2	12.8	12.9	12.7	12.7	15.6
Time on ice (hours)*	14676.2	14583.2	14608.2	14634.4	14821.2	15057.5	88380.7
Injury incidence density (per 1,000 hours)	67.3	68.0	41.0	41.3	39.9	39.4	49.4
Postseason	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	Overall
Injuries	57	59	27	33	29	25	230
Estimated athlete exposures (AE)	3078	3382	3230	3382	3382	3268	19722
Injury incidence density (per 1,000 AE)	18.5	17.4	8.4	9.8	8.6	7.6	11.7
Time on ice (hours)*	1012.9	1037.4	1051.3	1083.1	1099.7	1063.1	6347.5
Injury incidence density (per 1,000 hours)	56.3	56.9	25.7	30.5	26.4	23.5	36.2

Table 3. Game-related illness incidence density per 1000 athlete exposures and 1000 recorded player-hours. \*includes overtime minutes

Regular Season	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	Overall
Illnesses	39	52	28	30	29	32	210
Estimated athlete exposures (AE)	46740	46740	46740	46740	46740	46740	280440
Illness incidence density (per 1,000 AE)	0.8	1.1	0.6	0.6	0.6	0.7	0.7
Time on ice (hours)*	14676.2	14583.2	14608.2	14634.4	14821.2	15057.5	88380.7
Illness incidence density (per 1,000 hours)	2.7	3.6	1.9	2.0	2.0	2.1	2.4
Postseason	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	Overall
Illnesses	2	1	2	2	0	0	7
Estimated athlete exposures (AE)	3078	3382	3230	3382	3382	3268	19722
Illness incidence density (per 1,000 AE)	0.6	0.3	0.6	0.6	0	0	0.4
Time on ice (hours)*	1012.9	1037.4	1051.3	1083.1	1099.7	1063.1	6347.5
Illness incidence density (per 1,000 hours)	2.0	1.0	1.9	1.8	0	0	1.1

#### *Injury mechanisms*

The most commonly injured body regions were the head (20.1%), thigh (11.6%), and knee (9.2%) (Figure 3). Together these body regions also accounted for the greatest number of MGL, resulting in 16.7%, 10.5%, and 15.5% of total MGL, respectively (Web-only Figures 1 and 2). Mechanism of injury categories were added to the AHMS in 2009 and were coded for 1,877 (100%) injuries occurring between 2009-2012. Of cases where mechanism was reported, body checking accounted for the largest proportion of injuries (28.2%) as well as the most man-games lost (29.8%)(Table 4).

Table 4. Mechanism of injury reported during regular season and postseason games between 2009-2012.

Mechanism	Injury Frequency (%)	Man-games lost Total (%)
<b>Body check</b>	<b>536 (28.6)</b>	<b>4874 (29.8)</b>
Received	451 (24.0)	3916 (23.9)
Delivered	85 (4.5)	958 (5.9)
<b>Noncontact</b>	<b>277 (14.8)</b>	<b>1921 (11.7)</b>
<b>Incidental contact</b>	<b>268 (14.3)</b>	<b>2379 (14.5)</b>
<b>Hit by puck</b>	<b>253 (13.5)</b>	<b>2128 (13.0)</b>
Shot	236 (12.6)	2022 (12.4)
Pass	17 (0.9)	106 (0.6)
<b>Contact with environment</b>	<b>176 (9.4)</b>	<b>1617 (9.9)</b>
Boards	61 (3.2)	554 (3.4)
Ice	50 (2.7)	316 (1.9)
Glass	35 (1.9)	362 (2.2)
Board sills	27 (1.4)	335 (2.0)
Net	3 (0.2)	50 (0.3)
<b>Other intentional player contact</b>	<b>139 (7.4)</b>	<b>1168 (7.1)</b>
Elbowing	33 (1.8)	198 (1.2)
Slashing	14 (0.7)	207 (1.3)
Other stick checking	13 (0.7)	123 (0.8)
High sticking	5 (0.3)	15 (0.1)
Other	74 (3.9)	625 (3.8)
<b>Fighting</b>	<b>68 (3.6)</b>	<b>813 (5.0)</b>
<b>Unknown</b>	<b>160 (8.5)</b>	<b>1464 (8.9)</b>

### *Injury risk factors*

Compared to forwards, defensemen were more likely to report a game-related time loss injury (IDR = 1.21; 95% CI: 1.14, 1.28). There was no difference between defensemen and goalies (IDR = 1.06; 95% CI: 0.94, 1.21) or forwards and goalies (IDR = 0.88; 95% CI: 0.78, 1.00). There was no significant difference in reported illness by position. These ratios were identical using estimated AE and recorded time on ice.

Significantly more game injuries were reported at home (2,368; 51.5%) than on the road (2,229; 48.5%) (IDR: 1.06; 95% CI: 1.01, 1.13). The period in which the injury occurred was reported in 4,529 cases (98.5%). Injuries were significantly more frequent in the first period (2,177; 48.1%) than the second (1,152; 25.4%) (IDR: 1.89; 95% CI: 1.76-2.03) or third (1,104; 24.4%) (IDR: 1.97; 95% CI: 1.84, 2.12) periods. Sixty-one (1.3%) injuries occurred during the pre-game warm up, and 35 (0.8%) injuries occurred in overtime. Game-related injuries and illnesses were also unequally distributed over the course of each season (Figures 1 and 2). Specifically, injuries trend toward an increase nearing the end of the regular season, compared to the beginning.

Adjusting for diagnostic code, affected body region, and cluster by team, multivariate predictors of time loss following a game-related injury greater than 5 MGL were being a goalie (OR = 1.68, 95% CI: 1.18, 2.38), being injured in a road game (OR = 1.43, 95% CI: 1.25, 1.63), and mechanism of injury being a body check

(OR = 2.21, 95% CI: 1.86, 2.62). Age had no association with time loss. These relationships remained unchanged when examined for time loss of 2 MGL and 10 MGL.

## DISCUSSION

The purpose of this study was to report the rates of injury and illness in the NHL over 6 seasons, and to identify predictors of associated time loss. We have demonstrated that the time-loss injury rate obtained using estimated exposure is significantly lower than the rate obtained using recorded time on ice. The differences in the calculations are due to the fact that the game is played in shifts, with varying participation by each player. Over a typical game with 3 periods of 20 minutes stop-time, it is uncommon for a player to be on the ice for more than 30 minutes in total, with the exception of goaltenders who often play the entire game.

The roughly threefold difference in incidence between the two methods reflects the mathematical effect of players, on average, accumulating 20 out of 60 minutes of possible playing time. This difference in the reporting of injury rates has implications for comparing NHL injury rates with rates from other leagues. To illustrate, the injury rate calculated using estimated AE (15.6/1000 AE) is consistent with rates reported for North American collegiate players (13.8-18.7 injuries/1000 AE) [1-2,13] whereas the rate derived from recorded time on ice (49.4/1000 player game-hours) is more similar to reported injury rates from elite European leagues (66.0-79.2/1000 estimated player game-hours).[4-7,9] Interestingly, published injury rates for elite European leagues are based on data collected prior to 2009, and these are consistent with the rates seen in the NHL in the first two years of our study (67.3-68.0/1000 player game-hours).

Also of note, many previously published studies have not differentiated between time-loss and non-time-loss injuries when estimating injury rates, which might contribute to some differences in our results. This would not, however, account for a significantly lower injury rate in the NHL based on recorded exposure time compared to rates based on estimated exposure in other studies. It may be that the rate of injury in the NHL is in fact much lower than in other professional leagues, but this requires further investigation.

Most studies conducted in ice hockey have accounted for individual exposure time using attendance records at games and practices, but recorded time on ice is not feasible to collect in many settings despite being the gold standard for exposure registration. To facilitate between-study comparisons, researchers are advised to standardize estimates to rates per 1000 AE, acknowledging that in ice hockey 1 AE = 1 exposure hour. There have been recent advancements in alternative registration methods, including SMS messaging, [14,15] which may allow more accurate exposure estimates across age and skill levels. This may be a promising technique for future studies, although recording exposure by the minute is likely impractical in almost all settings.

Overall, there was a significant reduction in injury and illness over the last four years of data collection compared to the first two. Despite this overall reduction, within-season trends remained reasonably constant during the six years

of the study. Specifically, injuries appear to occur with greater frequency toward the end of the regular season, which contradicts the findings of Pinto et al, who found that injury frequency in Junior A hockey decreased in the latter half of the season.[16] However, given that the Junior A season consisted of only 48 games and the NHL season is 82 games, our results are not directly comparable. In the NHL season there may be an influence of fatigue and increased playing intensity as teams attempt to qualify for the post season, which would differ in timing from leagues with a different length of season. There was also a noticeable increase in illness during the month of February, which coincides with common influenza outbreak peaks in North America.[17]

Consistent with previous studies, we found that the injury rate was significantly higher in games than in practice or training.[7,12,16,18] We also found that the most commonly reported mechanism of injury was body checking, which is supported by the literature.[2,7,9,13,18] Previous studies have found that more injuries occur in the third period of games,[7,16,18] whereas our results suggest that injuries are more frequent in the first period. Because players are not fatigued at the beginning of a game, the speed of play is likely higher and players may be more physical, which may contribute to a greater risk of injury, but this is a speculative explanation. An alternate explanation is that, due to their high skill and fitness levels, NHL players might not fatigue as quickly as players in other leagues and therefore could be at a lower relative risk of injury during the third period than participants in other studies.

Although previous studies have consistently found that goalies are at a lower risk of injury than other skaters, there has been conflicting evidence suggesting that either forwards [4-5,7-8] or defensemen [6,9,16] are injured more frequently. In the present study, defensemen may have been at a higher risk of injury due to the physical style of play associated with that position. This is supported by our finding that incidence density ratios between defensemen and forwards are identical using both AE and time on ice, suggesting that the difference is not the result of playing time differences between the two positions, but a product of the playing position itself. Additionally, we found that time-loss injuries were more frequently reported during home games than road games, possibly due to the immediate accessibility of home team physicians in home arenas.

Predictors of time loss greater than five MGL were being a goalie, being injured by a body check, and being injured during a road game. Other factors that were associated with injury incidence (ie: time of season, age, game period) did not predict time loss when included in our multivariable model. Due to the physical demands of the goaltending position and the importance of goaltending to team performance, additional caution may be taken when clearing these athletes to return to play following injury. This would account for the greater time loss reported for goaltenders, even after adjusting for injury type and location. Body checking is an important factor in time loss injuries, particularly because it is the most frequent mechanism of injury in the NHL. Finally, time loss may be elevated for injuries sustained on the road due to the reduced accessibility of team physicians and immediate referred services away from home.

## **Limitations**

The data included in these analyses were collected through team trainer/therapist and physician reports, and the extent to which injuries were underreported could not be measured. It is also unknown whether different reporting and return-to-play practices existed between the physicians of different teams. However, utilization of the AHMS is mandatory within the NHL, and the injury surveillance occurs seamlessly in the background, so potential underreporting is likely to be a minimal bias. One of the strengths of the study is that the AHMS system has enabled consistent data collection to occur over six seasons, which is often a challenge in other cohort studies due to diminishing compliance over time.

Mechanism of injury categories were only coded for a portion of injuries occurring between 2009-2012, so the accuracy and completeness of these data are limited. Consequently, there was a reduced sensitivity to account for changes in mechanism of injury trends over the duration of our study. The generalizability of our results is limited to adult male professional ice hockey players.

## **CONCLUSIONS**

This study provides evidence that there was an overall reduction in time-loss injury and illness rates between the 2007-2008 and 2008-2009 NHL seasons. Being a goaltender, being injured on the road, and being injured by a body check were risk factors for time loss greater than five man-games.

Because different conclusions about injury and illness risk may be drawn based on the denominator used in rate estimates, it is recommended that future studies be consistent in documenting and reporting their method of calculating exposure. Future work to determine the validity and reliability of alternative exposure registration techniques in this population, such as SMS, is recommended.

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**CONTRIBUTORSHIP:** WM designed the study and is responsible for the overall content. CM, RT, and BS prepared the manuscript.

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**Figure legends:**

Figure 1. Game-related injury frequency by month of the regular season.  
(\* NHL hiatus for Olympic Winter Games)

Figure 2. Game-related illness frequency by month of the regular season.  
(\* NHL hiatus for Olympic Winter Games)

Figure 3. Injuries by body part.

**Web-only figures:**

Figure 1. Injury frequency by body region.

Figure 2. Man-games lost by body region.

Pre-publication

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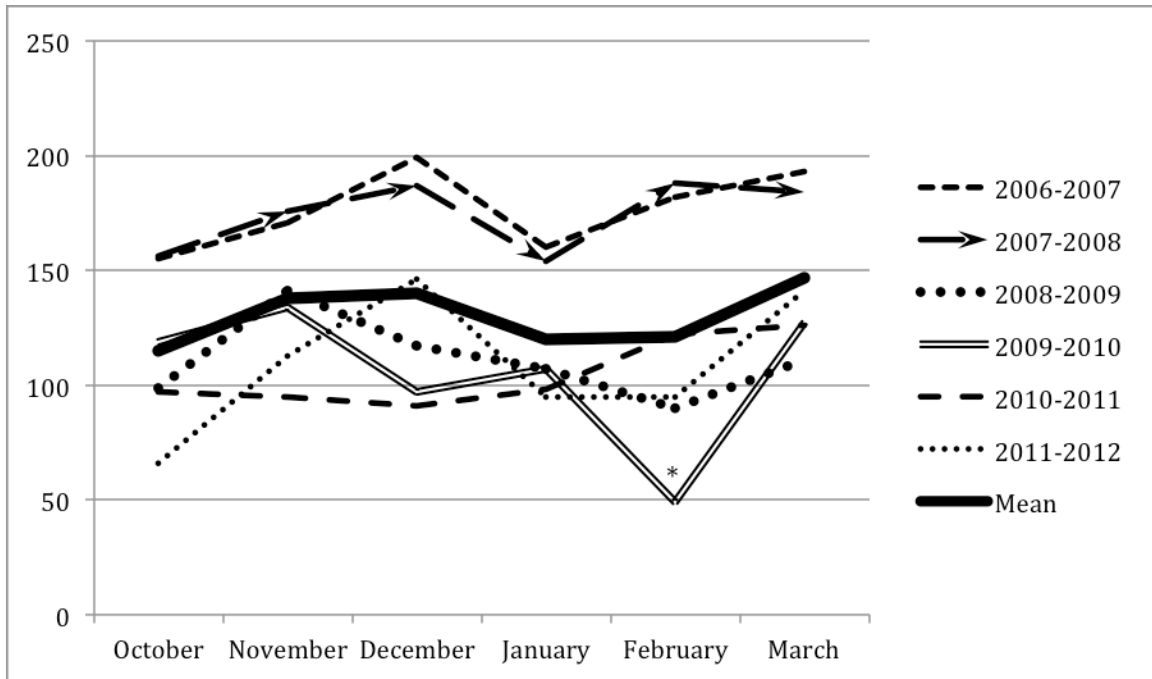


Figure 1

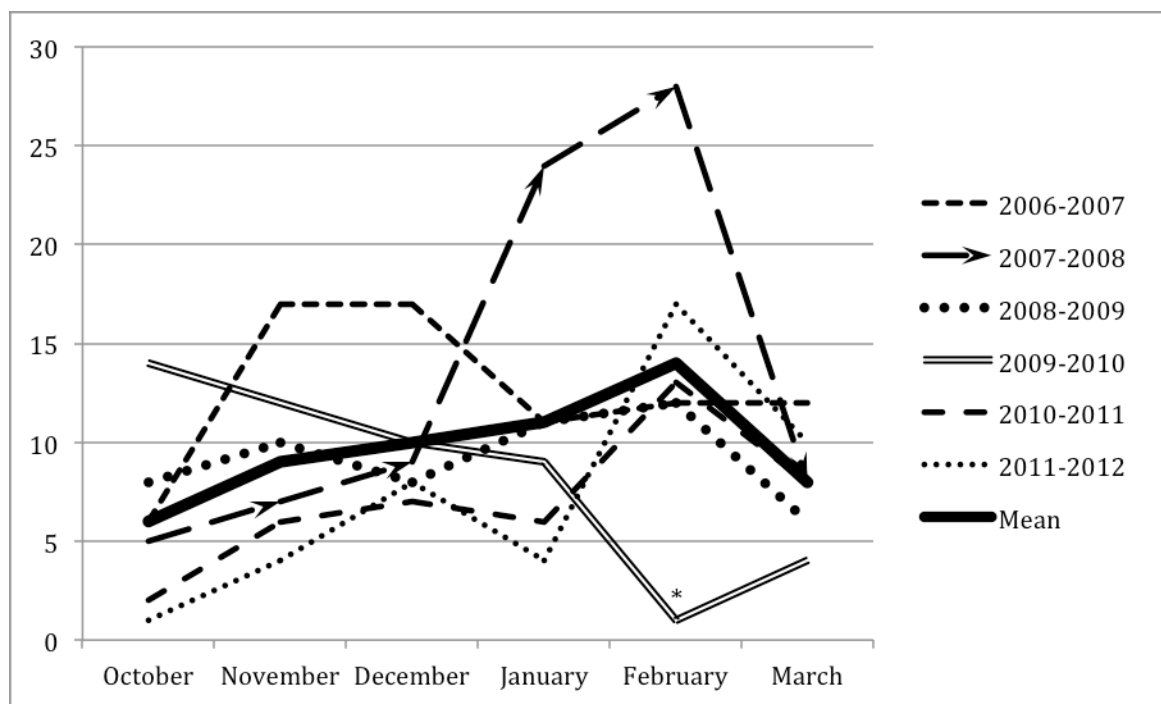


Figure 2

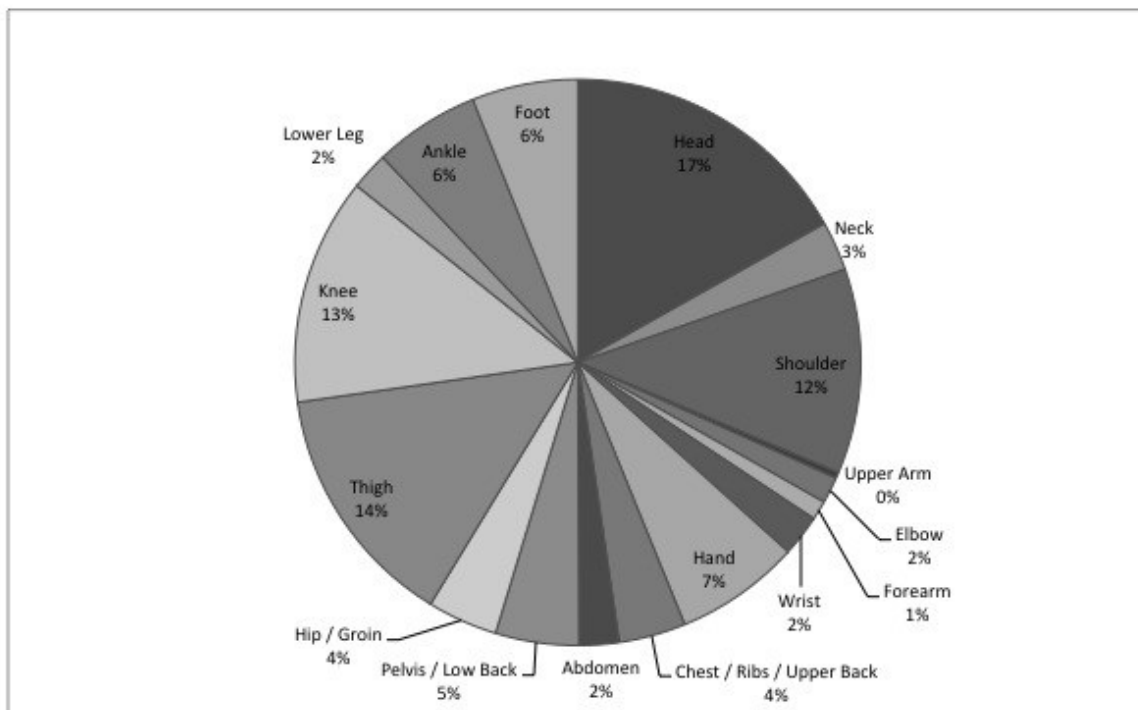
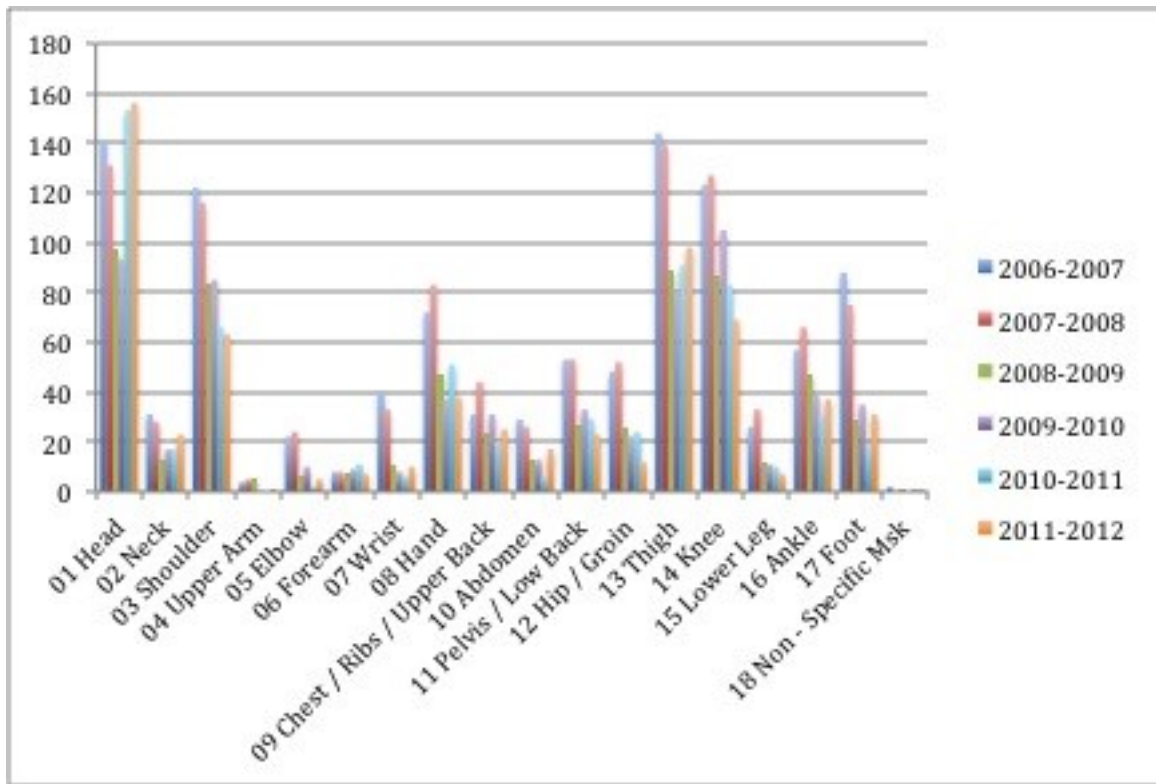
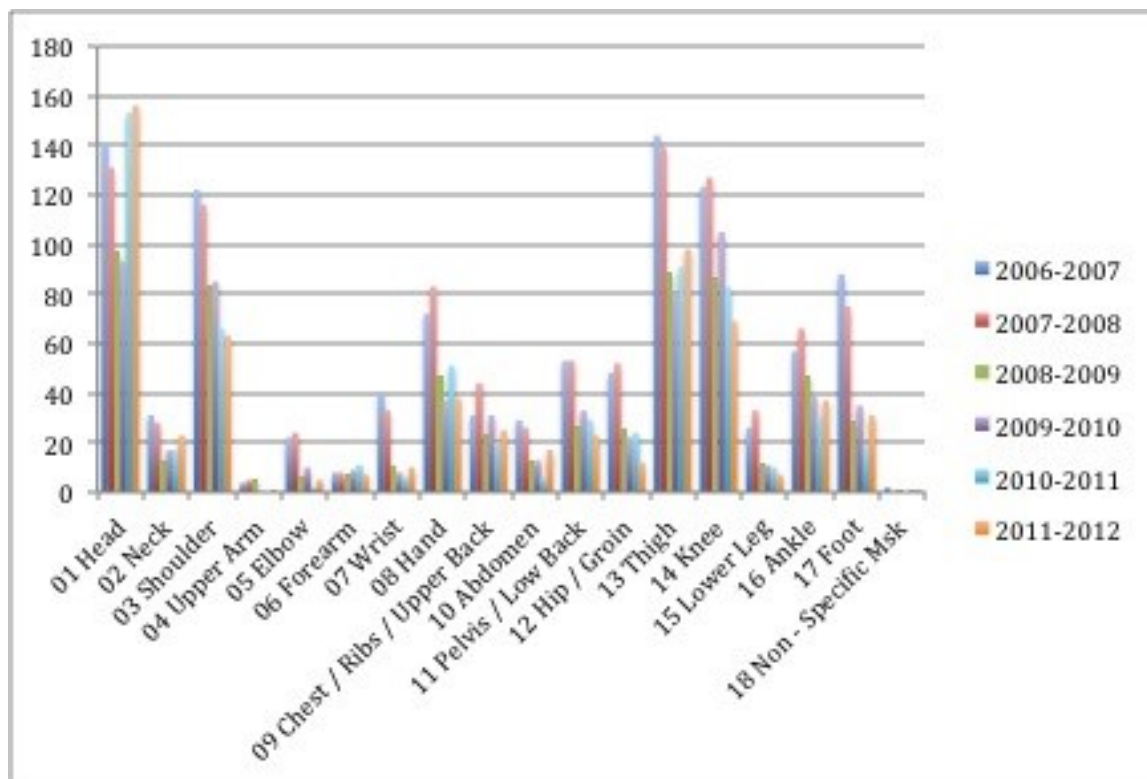


Figure 3



Web-only 1



Web-only 2